TOWARDS A TRANSFER MODEL OF SCIENTIFIC AND TECHNOLOGICAL KNOWLEDGE: THE CASE OF MEXICO

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Abstract: This paper shows the development of a science-technological knowledge transfer model in Mexico, as a means to boost the limited relations between the scientific and industrial environments. The proposal is based on the analysis of eight organizations (research centers and firms) with varying degrees of skill in the practice of science-technological knowledge transfer, and carried out by the case study approach. The analysis highlights the synergistic use of the organizational and technological capabilities of each organization, as a means to identification of the knowledge transfer mechanisms best suited to enabling the establishment of cooperative processes, and achieve the R&D and innovation activities results.
Keywords: Knowledge transfer, Technology management, Innovation management, Case Study.

1. Introduction

The big economic advances happened recently in different countries are narrowly related to the process of innovation and generation of knowledge. Nevertheless, it is not only the creation of knowledge what counts, but the flow of this knowledge to the company and the aptitude to absorb and transfer this knowledge. Thus, recognition of the interactive nature of the innovative processes has resulted in an early differentiation between innovation (knowledge production) and diffusion (knowledge flow). It is clear that merely possession of knowledge does not guarantee a success at a competitive level (Mu et al., 2010).

From the knowledge transfer (KT) viewpoint is just the interactive nature of innovation that leads to the perception of the links between the system of knowledge production and the production of goods as key role (Tang et al., 2010). Indeed, in the last years most part of studies related to KT have been oriented on the need for a close cooperation between universities and industry, pointing out the forms, benefits and current barriers (Link and Siegel, 2005; Numprasertchai et al., 2009). From this perspective, National Innovation Systems (NIS) operates by means of the introduction of knowledge in the economy and through a series of interconnected organizations (Lundvall, 1992; Nelson, 1993; Etzkowitz and Leydesdorff, 1997). The transfer of knowledge can occur in several ways: integrated in equipment and personnel, built in patents and licensing, publications and documents, informal networks or skills (OECD, 1996). However, these interactions are not exempt from some restrictions because the existence of various channels of interaction within the NIS determines the degree of diffusion and transfer of knowledge. The effectiveness of such channels is dynamic in nature and varies with the type of knowledge, the purpose of interaction, and the communication status (Polanyi, 1996). Another restriction is the approach developed with regard to the expected results, because while the science environment have a long-term approach (papers, theories, methodologies), firms environment have a short-term approach (patents, high-tech products or process), thus forming two distinct cultures (Chiesa and Piccaluga, 2000; Siegel et al., 2004). However, beyond the lack of mutual understanding is the poor knowledge and weak participation through the various transfer mechanisms.

In the National Innovation System of Mexico it is possible to identify a gap between the generation, transformation and application of knowledge. In general, the line followed by the most of research centers has been to provide human resources to firms, acting like a spectator of industrial and economic development of the country. While there is some evidence of the problem, the reasons behind these are still without explanation. In fact, knowledge is not just limited to the scope of basic science; there are other research institutes dedicated to applied research and technological development (R&D). Other evidence emphasizing this gap it is observed when the limited investment by firms in R&D and knowledge transfer has been carried out through purchase capital goods and technology products to solve problems in the short-term, and to a lesser degree of investment in know-how and scientific knowledge.

In general, the studies to obtaining evidences about this problem in Mexico are very limited and mainly focused on topics such as types of knowledge, networks and linkages. The different mechanisms to transfer knowledge are omitted, and the few results show the lack of interest from industrial firms in technological R&D to use it as a factor in raising competitiveness (Casalet and Casas, 1998). These evidences indicate that there is an important weakness in the analysis of KT processes between scientific and industrial environments. Taking into account this scenario, the purpose of this publication is to contribute to the study of KT in Mexico based on the following research questions:

(1) What are the current mechanisms that employ both research institutes and enterprises to perform the knowledge transfer?
(2) What are the processes used by research centers (public and private) to develop R&D, and knowledge generation, as the processes used by the firms to apply knowledge and to innovate?
(3) What are the factors that have influenced those organizations that have implemented KT mechanisms getting successful results?
(4) What are the degree of understanding of the processes of KT and its importance in the economic, cultural and social part of the scientific and business-industrial?

This paper is structured as follows. The second section briefly describes the theoretical framework on the subject in order to describe in the third section the methodological approach and research design applied. The fourth section describes the findings on the analyzed cases. Finally in the fifth section a summary of the findings is presented.

2. Importance of cooperation in knowledge transfer between university and enterprise

Developed countries actually are experiencing processes that tend to form their firms and industries into knowledge-based economies (KBE). In this development the flow of goods in most economic areas has been gradually replaced by the flow of knowledge and information. Therefore, due to the intensity of the international competition is continuously increasing, countries are pressed to improve their capabilities to rapidly generate and disseminate knowledge (Fisher, 2001; Gyeung-Min and Eun-Sook, 2008). According to this fact and from the point of view of cooperation, it is precisely this systemic and interactive nature of innovation that has led to the perception of the links between the system of knowledge production and its application in goods/services as key role. Consequently, this relationship has become more systemic and less casual.

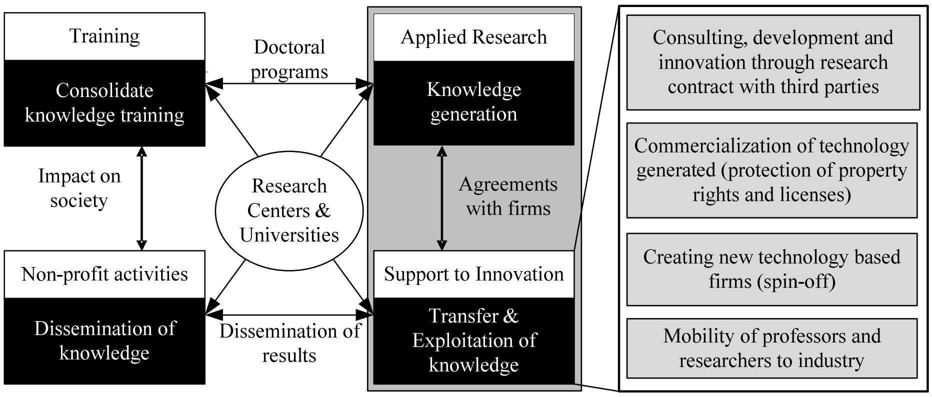
While in a world of increasing competition and rapid technological change the access to external knowledge, experience and cutting-edge research provide an incentive for a company to seek the cooperation with research centers (Kess et al., 2008), for them the interest in collaboration is stimulated by factors such as financial pressures (to see the economic value of public research and seeking co-funders from the private sector), and the interest of researchers to capitalize the results of their work when the results applied in industry are relevant (Feldman and Bercovitz, 2006). However, in firms there are also factors that facilitate or hinder their capability to cooperate in KT with other actors in this process, not all firms are equally ready to collaborate with research centers or willing to do so.

The greater or lesser facility for firms to cooperate with research centers depends on characteristics such as: size, industry, technical training, and attitude towards innovation. Cohen et al. (2002) demonstrate the variety of mechanisms used by industry to access and interact with the research centers. The study indicates that public research is used not only to help to generate new ideas, but also to help to complete the R&D available projects. According to Hidalgo and León (2006), firms are involved in all public research functions in different ways:

- In the activity of knowledge generation, financing or assisting in research projects. This support is normally through schemes of research under contract, strategic alliances leading to long-term support of certain lines of inquiry (eg. setting up joint R&D), or through the creation of spin-offs.
- In training, financing, organizing or providing experts in courses or seminars tailored to their specific needs or collaborating on programs for mobility of teachers and pupils and their own technical staff.
- Finally, some agreements with research centers and universities can support the dissemination of results to society.

The situation leads necessarily to take the generation, transfer and exploitation of knowledge, and emphasize the differentiation of the mechanisms through which it is possible to fulfill this mission in relation to firms (Hidalgo and León, 2006; Gulbrandsen and Slipersæter, 2007; Montesinos *et al.*, 2008) (Figure 1).

Figure 1. Cooperative activities related to KT and the third mission of the university.



In this context, there are many paths or ways of interaction that can be adopted by firms and research centers for knowledge transfer (Al-Agtash and Al-Fahoum, 2008). The term transfer covers the diffusion and cooperation (technological) among organizations, sectors, regions or countries. In the empirical literature about the different ways of transferring knowledge and technology we can find different forms (Bozeman, 2000; Schartinger et al., 2001; Schmoch, 2003). The one selected will depend on the sector, the national circumstances, and the technology type or knowledge. This means that to properly transfer the knowledge it is required to align both the type of knowledge and the scheduled task (Nadler and Tushman, 1999; O'Sullivan et al., 2007).

3. Research methodology

The research was carried out through the case study approach because it is a method that helps to understand in depth the dynamics present within individual scenarios and discover new and complex relationships and concepts (Eisenhardt 1989; Yin 1994; Worley and Doolan, 2006). The case study as example of real experience of the organizations is able to show their own stories about the development of change in practice and how the content, context and change policies interact (Dawson, 1997). Yin (1994) defines the term as an empirical question that "investigates a contemporary phenomenon within its real life context when the boundaries between phenomenon and context are not clearly evident which use multiple sources of evidence".

In order to answer the research questions raised in the first section, the scope of the research has been delimited to the context of eight Mexican organizations (four research centers and four firms) with experience in KT processes located in different geographical regions and belongs to different industrial sectors (Table 1).

Table 1. Description of research centers and firms.

Research Centers
CIATEQ, It develops metal-mechanic products, processes and systems capable of generating competitive advantages which usually involve business of designing, prototyping, installation and commissioning of machinery and equipment. There are thirteen lines of research aimed at technological development and consulting. It has cooperation and KT agreements with both educational and specialized institutions, and research centers, as firms (all national and international organizations).
CCADET, was created at UNAM (National Autonomous University of Mexico) in response to the problems of scientific and didactic instruments. In 80's focused on the research and technology development, and 90's was created the Coordination of Linkages with the purpose of transfer and disclose to the industrial society and sectors related the S&T knowledge generated by the R&D laboratories. It has cooperation agreements with public and private organizations, non-profit associations, and internal organizations.
LANIA, is a research center in information technology (IT), whose goal is developing R&D and innovation projects, training of specialists and technology transfer in IT. Providing training and updating of high level through academic programs that include postgraduate and graduate programs. It has cooperative and KT agreements with research centers (public and private) and firms.
LATEX, is a research center at Autonomous University of Veracruz (UV) in the areas of natural resources, environmental and biotechnological processes. It offers research services, analysis, technical assistance and specialized training, support human resource training, and inspection, testing and quality control. It has collaboration agreements with universities, institutes and organizations.
Firms
SILANES, as a pharmaceutical firm, in 1995 promoted the use of bio-technology and genomic medicine. In 1990, was founded the Bioclón Institute, creator of the third generation of antivenoms with technology 100% owned. Bioclón maintains alliances with the main educative institutions and public research centers, as well as agreements with public and private health organizations national and international.
MABE. Manufacturing appliances and white goods. In 1994, was founded the Center for Technology & Projects where all the projects of R&D and innovation are analyzed and managed. It has cooperative and KT agreements with research centers (public and private) and firms (partners, customers, suppliers) nationally and internationally.
SYCSA. Manufactures and distributes equipment for handling, storage and transportation of bulk materials. In 2003 was founded the first Technology Development Center, whose purpose is the generation of high-value technology and innovation, also establishing knowledge networks and strategic alliances with other organizations.
STREGER. Produces, manufactures and distributes chemicals and pharmaceuticals goods. To develop new products or processes, the product development laboratory and quality control department establish links with external research centers, promoting knowledge acquisition based on staff training and acquisition of software tailored to the identified needs.

The selection of these firms has been motivated by the fact that each presents a different profile from the perspective of knowledge transfer, which helps to differentiate the mechanisms used and the efficiency in use, and they have capacity to generate knowledge.

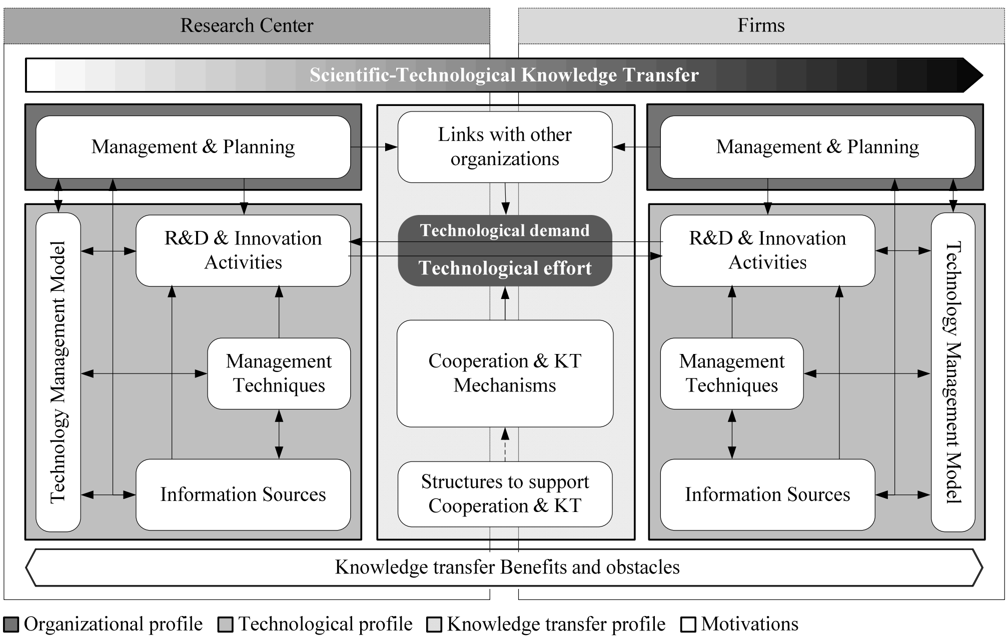
The information obtained from each organization is of two types: primary information, obtained through personal interviews through a questionnaire designed for that purpose; and, secondary information, obtained from various resources (annual reports, internal documents, etc). The comparison of the eight case study is based on the fact that, once that the information from each organization has been obtained (where the research center o firm is the unit of analysis) and following an iterative process (between qualitative and quantitative data), this analysis has helped to understand the function of each organization and identify their similarities and differences. In this way, the objectives of the analysis point to enrich the results of individual cases by analyzing all the data in various ways, and building a logical chain of evidence in order to compare the results with existing literature (Eisenhardt, 1989). The evidence reflected the emergence of a new way of seeing and understanding the results in order to identify those critical factors (positive and negative) in the KT process.

This research methodology has been used by different authors among which stands out Cobbenhagen (2000). This author, in his research about the innovation management in small and medium-sized enterprises, found that knowledge about the factors behind the innovative organizations cannot be obtained only through the collection and measurement of hard data (R&D expenses, financial data, production time, number of innovations). The knowledge is within the data, which stems from the perception and meaning of these metrics, and the characteristics and organizational processes more widespread that allow an organization to be successful over a long period of time.

4. Proposed model analysis

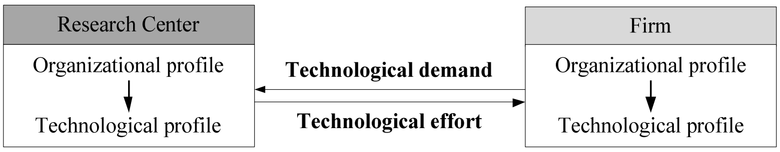
The analysis in depth of the various aspects that underlie the KT model processes shows that those organizations that have succeeded in these processes have many distinctive features which facilitate or hinder these. Then, the establishment of KT agreements in the sample is usually the result of the synergistic combination of such aspects which includes: organizational profile (organizational characteristics and management system); technological profile (R&D and innovation activities, information sources, management techniques, and technology management models); knowledge transfer profile (KT mechanisms, links with other organizations and structures to support KT); and motivations (impacts-benefits and obstacles). The model shows the relationships of influence between those profiles aiming to develop knowledge transfer processes (Figure 2).

Figure 2. Scientific-Technological Knowledge Transfer Model.



So, the model responds to the question of how to align the internal R&D and innovation activities in the analyzed organizations to the KT processes developed with other organizations. So, the model represents the relationships of influence between the R&D and innovation activities and KT processes (Figure 3).

Figure. 3. Effort technology-demand technology relationship.



4.1.Organizational profile

4.1.1 Organizational characteristics

For the research centers is emphasized that origin and industrial sector to which they belong play a fundamental role in their configuration. The origin and the industrial sector, have an important influence in the development of products and services offered by these research centers (Table 2). However, the technological level of the services and the type of S&T resources (human, material and economical) dedicated to these services, are determined by the industrial sector to which they decide to focus its S&T efforts. LATEX case is highlighted because although LATEX develops activities of a medium-high technology sector (chemicals), the industrial sector (agro-industry) to which they dedicates these efforts is considered a low-tech sector, and of low tendency to invest in activities of R&D and innovation.

Table 2. Organizational profile of the research centers.

CIATEQ	CCADET	LANIA	LATEX
Grande		Micro	
Origin in the industry	Origin in the university	Origin in the private sector	Origin in the university
30 years	37 years	17 years	11 years
Public/Private capital	Public capital	Private capital	Public/Private capital
Business units organization	Multidisciplinary units organization	Hierarchic structure organization	Hierarchic structure organization
Medium-high to high tech		High tech	Medium-high to high tech
Several products and services in many varieties			One service in many varieties
Strategic plan			
Technological plan			

For firms, factors such as origin and technological level of the region play a vital role in their configuration. But, unlike research centers, the origin is determined by the demand or market needs. The technological level of the geographic area over which they are located has been a key factor to promote the creation of an innovator environment that favors the development of S&T activities. So, research centers and firms construct the basis that will allow developing their main activities (Table 3).

Table 3. Organizational profile of the firms.

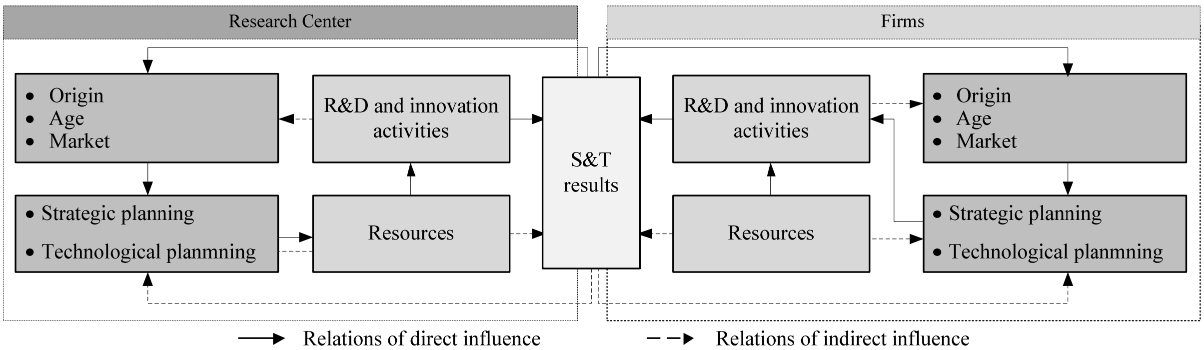
SILANES	MABE	SYCSA	STREGER
Big firm	Big firm	Medium firm	Small firm
Geographical region of high-tech	Geographical region of high-tech	Geographical region of low-tech	Geographical region of low-tech
Decentralized organizational approach	Decentralized organizational approach	Organizational approach in transition	Centralized organizational approach
High-tech sector	Medium-hig tech	Low-medium tech	Medium-high tech
Products and services: Pharmaceutical, biotech	Products and services: Electronics, home appliances and consumer	Products and services: Storage and transport of fluids.	Products and services: Pharmaceutical.
Several products and services in many varieties	Several products and services in many varieties	Several products and services in many varieties	Several products and services in many varieties
Strategic plan			
Technological plan			

4.1.2 Management system

The management of these organizations is carried out through three basic tools: the strategic plan; the technology plan; and the quality management system or policies and procedures, which standardize, align and guide the development of S&T activities. The technological planning of the research centers is a fundamental process within the strategic planning process, however, there are important differences regarding how to develop technology planning. This is because although all the research centers have the capacity to respond to a homogeneous community (R&D and innovation services, teaching, or training.) in the area where they operate, their origin (industrial or university, public or private) and orientation of their activities (basic or applied research, technological development, innovation, teaching, training) determine the degree and intensity of their participation in such S&T activities.

For firms, the application of these tools has emerged more as a need to respond to various factors such as changing market conditions, competition, the annual results, or the exploration of new markets; but, unlike research centers, technology planning is determined by market needs and competition. The development of the technology plan of the most experienced firms is supported by the technology watch processes. More sophisticated mechanisms can range from product tracking in specific projects to external systems using technological intelligence (Figure 4).

Figure 4. Strategic and technological planning in research centers and firms.



The resulting information (in the form of strategic and technological actions) of such planning activities determines, the methodological approach applied in relation to situations and problems found during the management of S&T activities (called "technology management model"), and the complexity of the tools and techniques used for the R&D management with respect to several presented scenes.

4.2.Technological profile

4.2.1. R&D and innovation activities

The analysis shows that development and intensity of R&D and innovation activities is reflected in results and building S&T capabilities. But, the building of such capabilities is not confined to internal R&D and innovation activities, because such knowledge can be acquired in other ways. For the research centers, the number and development degree of R&D and innovation activities reflect the organizational maturity developed by these throughout their life cycle. However, these aspects are not the only ones that have influence on what and to what extent developing their S&T activities. In this context, some research centers developing their S&T activities under an approach supported in the innovation linear model, whereas others do it under an interactive approach (Bush, 1945; Schmookler, 1966; Kline and

Rosenberg, 1986).The innovating approach chosen have a significant impact on the manner, infrastructure and resources that are engaged in such activities (Table 4).

Table 4. The innovation model and the R&D activities in research centers.

CIATEQ	CCADET	LANIA	LATEX
Innovation approach			
■ 3a. Generation	■ 1st and 2nd Generation	■ 2nd and 3rd Generation	■ 1st and 2nd Generation
R&D and Innovation activities			
■ Applied research, technology development and product innovation in various fields.	■ Basic research, applied research, and technological development in various fields.	■ Applied research and product innovation in various fields.	■ Basic research.
Research lines or priority areas of knowledge			
■ Machines and processes for manufacturing, measurement and instrumentation, monitoring and control systems, alternative energy.	■ Instrumentation, micro and nanotechnology, information technology, S&T education.	■ Networks and distributed systems, AI and multiagent systems, and bio-inspired algorithms.	■ Diagnosis of plant health, food safety and quality.
Resources and results			
■ Staff with doctorates, masters, and bachelor's degree. ■ Scientific results: 142 papers, 2 patents, and 6 softwares.	■ Staff with doctorates, masters, and bachelor's degree. ■ Scientific results: 312 papers, 65 book chapters, and 15 softwares.	■ Staff with doctorates, masters, and bachelor's degree. ■ Scientific results: 53 papers, 8 book chapters, and 9 prototypes.	■ Staff with doctorates, masters, and bachelor's degree. ■ Scientific results: 12 papers, 2 bokk chapters, and 1 book.

For all analyzed firms the R&D and innovation activities are a key factor in its success, the manner and extent to which this type of activity varies widely among all (Table 5). This aspect is partly due to the heterogeneity and the strategies chosen by these organizations to carry out their activities. In fact, the number and development degree of such activities reflect the organizational maturity developed by all firms throughout their lifecycle. In the analyzed firms these aspects are not the only ones that have influence on what and to what extent developing their S&T activities. The innovating approach chosen have a significant impact on the manner, infrastructure and resources that are engaged in such activities.

Table 5. The innovation model and the R&D activities in firms.

SILANES	MABE	SYCSA	STREGER
Innovation approach			
4th Generation		■ 2nd. Generation	■ 3rd. Generation
R&D and Innovation activities			
■ Basic research, applied research, technological development and innovation in various fields.	■ Basic research, applied research, technological development and innovation in various fields.	■ Mostly technological development and innovation of products and processes.	■ Basic research, applied research, technological development and innovation in various fields.
Industry Sector			
■ Pharmaceutical, biotech.	■ Electronics, home appliances and consumer goods.	■ Storage and transport of fluids.	■ Pharmaceutical.
R&D and Innovation expeditures*			
■ 23%**	■ 1%	■ 0,02	■ 40%***
Resources and results			
■ Staff with doctorates, masters, bachelor's degree, technical and external [illegible] ■ Scientific results: 20 papers, 2 patents & 2 trademarks.	■ Staff with doctorates, masters, and bachelor's degree. ■ Scientific results: 4 patents by year.	■ Staff with bachelor's degree.	■ Staff with , masters, and bachelor's degree. ■ Scientific results: one patent.

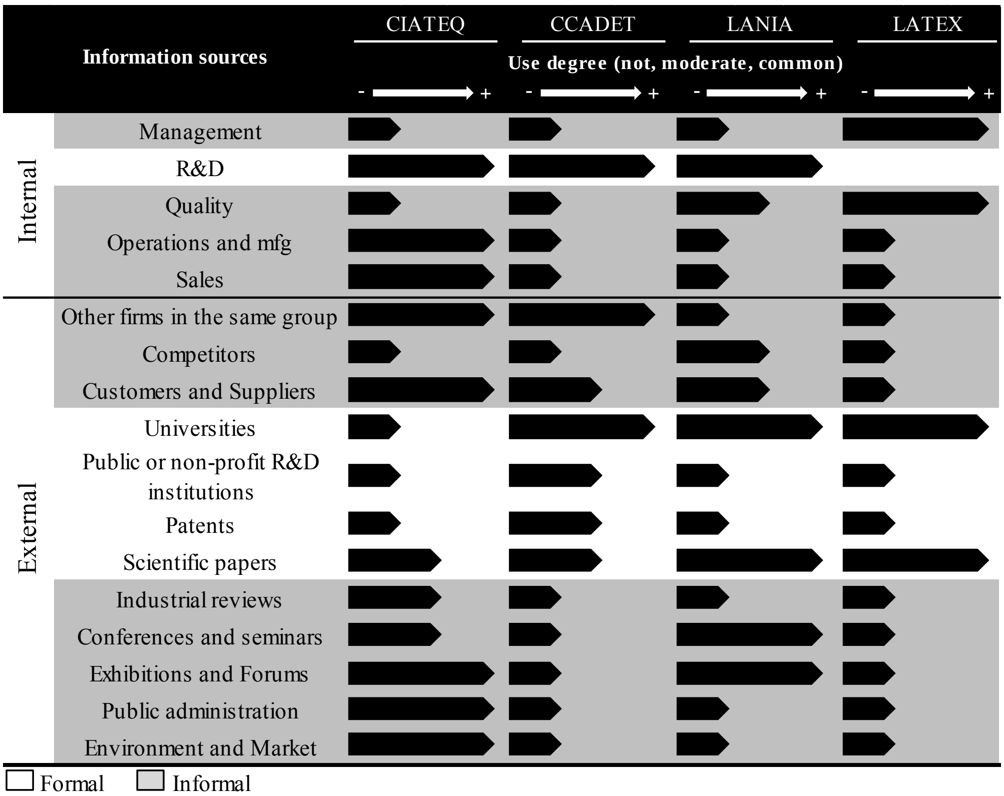
* As a percentage of sales, **includes formal and informal training, *** Including infrastructure and equipment.

S&T activities of SILANES and MABE are not supported by traditional innovation approaches (such as the linear model or the interactive model), as more advanced models such as the innovation model of Schmidt-Tiedeman (1982) or Roberts (1988); by contrast, in the most developed research centers (like CIATEQ and CCADET), there is a trend toward using more advanced innovative approaches. The fact that analyzed firms develop various R&D and innovation activities in different degrees implies the extensive variety of resources to acquire knowledge, facilitating also the learning and acquisition processes. This confirms the relationship between the innovation approach used by firms and R&D and innovation activities developed. From the perspective of KT, the approach strongly determines the sources that are used when conducting these activities and the type of relationship established.

4.2.2. Information sources for the management of the R&D and innovation

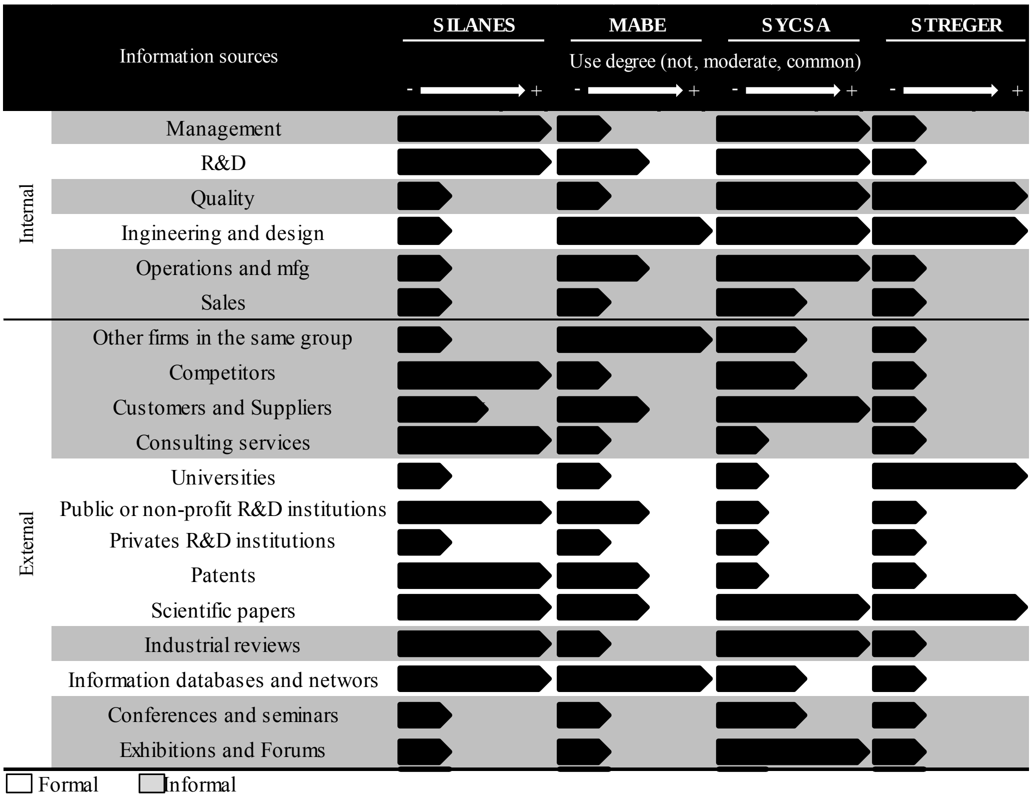
Traditionally, obtaining information for R&D management and innovation activities is based on the access to specialized literature, despite there are other information sources of great relevance for decision making which include: internal (R&D, engineering, quality, production, sales), and external (scientific publications, patents, competitors, customers, suppliers, universities, etc). In the research centers, their main information sources are the internal R&D departments; externally, the variety and heterogeneity of sources that use all research centers emphasizes the profiles shown above (Table 6).

Table 6. Sources of information for the management of R&D and innovation in research centers.



For the analyzed firms, the information sources are intended to provide knowledge to generate innovations which affect the development of new products and processes (Table 7). At the organizational level, innovation is synonymous for technological learning that is manifested through the creation and implementation of new technological knowledge in routines and S&T activities. On this basis, the firms develop their products and services and build their skills using several information sources. Therefore, firms also highlights the variety and heterogeneity of sources to use, and indeed for most of firms, the process of searching information is not a linear process or isolated, rather is a process given throughout the innovation process using a variety of sources in an interdisciplinary way.

Table 7. Sources of information for the management of R&D and innovation in firms.



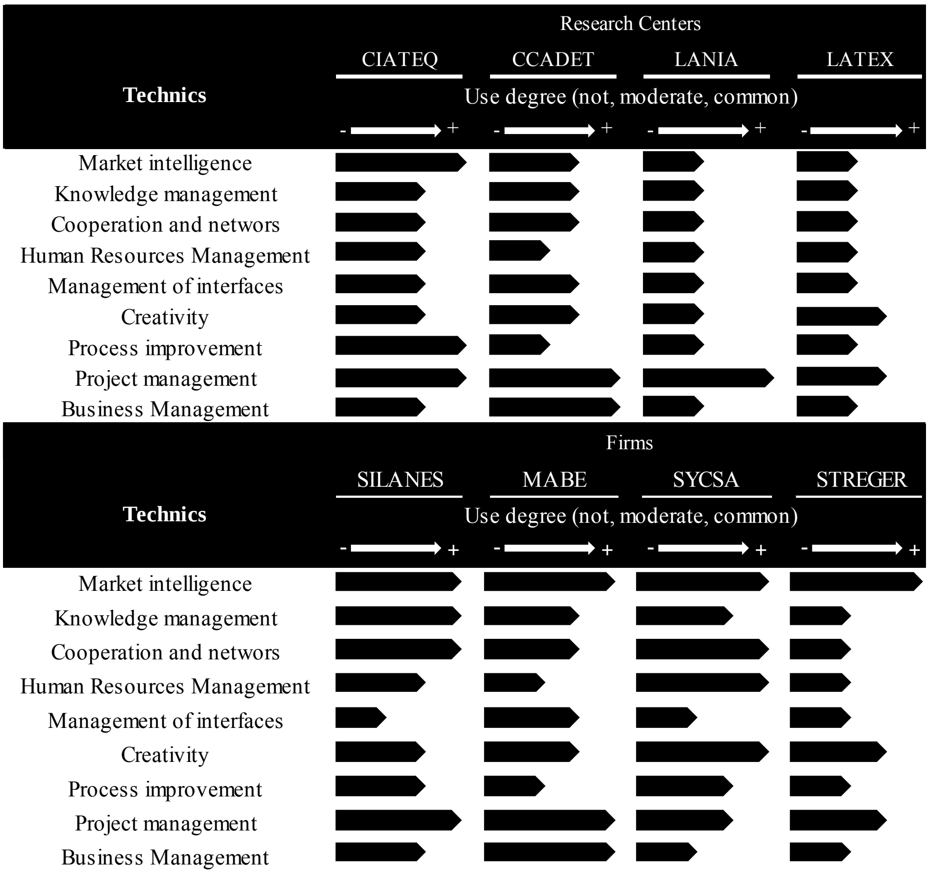
A characteristic that determines the sources of information used by the research centers is the origin and environment in which they are located. For those centers whose origin and environment was the university, their information sources are based on science (STI-mode); while those research centers whose origin was the industry, their information sources are based on innovation (DUI-mode). All research centers highlight the significant role of S&T activities as the main information source to carry out their R&D and innovation activities. The analyzed firms use mainly information sources based on the technological sector to which they belong and the type of products and services they provide. Nevertheless, all firms use in major or minor degree both types of sources, highlighting the innovative approach taken in developing their S&T activities.

4.2.3. Techniques for the management of R&D and innovation

To support the use of various information sources as a means to improve knowledge management, and boosting the absorptive capacity and management of R&D and innovation, firms have implemented various techniques that enable them to manage knowledge throughout the process of R&D and innovation management. In this context, it refers to techniques that are classified on the basis of the main pursued objectives, the experience in its management and its level of sophistication (Hidalgo and Albors, 2008).

The techniques more used are those focused on the market intelligence (which could be considered the early stages of R&D and innovation management), the project management and the process improving (which facilitate the implementation of the innovations resulting from the management of S&T activities). In the case of research centers, the experience and maturity has been a key factor in applying these techniques to manage the R&D activities (Table 8). However, is emphasized the fact that some research centers in the university environment commonly do not use some techniques (such as CRM or SCM). The use of these techniques is limited mostly (except CIATEQ) to use traditional techniques (such as project management, teamwork, brainstorming, etc.), and to a lesser degree more innovative tools (such as patent analysis, knowledge management, skills management, TRIZ, etc).

Table 8. Analysis of management of R&D and innovation techniques in research centers and firms.



The analysis of the application of these techniques shows also that most firms use them widely, partly due to needs to maintain a competitive level with respect to other firms, whether to develop new products and services and to improve existing ones. However, the S&T results in some firms such as SYCSA and STREGER shows the important influence by the sector, the type of products and services offered, and the technological level of the region in which they are located, as favoring elements in an innovative environment and promoting the use of such tools.

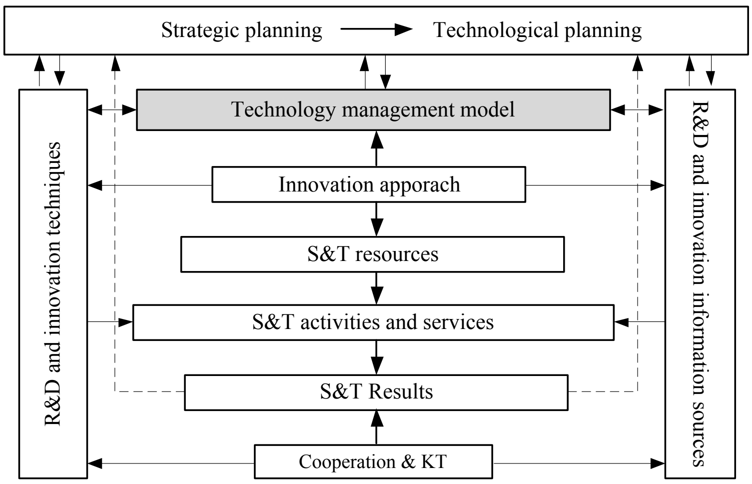
It is emphasized both the extensive experience developed by MABE and SILANES in the use and application of these techniques as the level of sophistication of them. In fact, technological assets of firms has increased as a result of use of these tools and techniques (monitoring and forecasting technology, map knowledge, management of the supply chain, etc), acting like facilitators in the integration processes and assimilation of technology, and better manage intellectual property. Most of firms have specific areas to technology management, which are integrated throughout process of S&T development to facilitate the technological assimilation from the beginning of planning. The ultimate goal is to capitalize the externally acquired knowledge and internally developed to make it available to staff through various means (such as documents or databases, training, software, etc). However, although these techniques are useful for efficient management of the R&D and innovation processes based on scientific knowledge, it is perceived that most organizations do not have a real awareness of benefits arising from the application of these tools and their scope. Information sources now are seen more as part of the administrative techniques, as tools of strategic management of R&D, innovation and KT.

4.2.4. Technology management model

In this context the success achieved as a result of application of these tools becomes more evident when it is observed that those organizations with a technology management model takes into account, implicitly or explicitly, various techniques for the management of R&D and innovation. However, such models have not been the result of chance, but the result of experience obtained by the practices in technology management and organizational maturity developed by such organizations.

On the basis of comparative analysis there is a relationship among the assessed factors and the technology management model in each organization. So, it is possible to identify the advantages of having a technology management model, which lie in the fact that integrates various functions and processes, which help to develop S&T activities beyond the boundaries of the areas and the typical functions of R&D and innovation, and takes into account the resources and results of these S&T activities throughout the process of technology management (Figure 5).

Figure 5. Integrating the technology management model in the R&D and innovation activities.

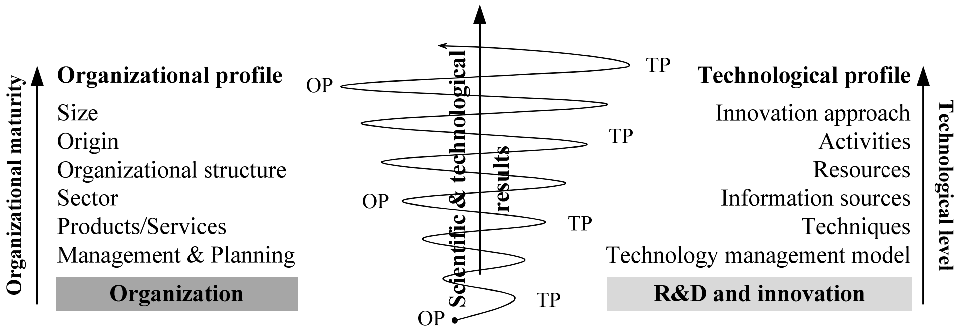


CIATEQ research center has developed its own technology management approach to through which resolves the several presented scenes. Highlights the case of CCADET technology management model, because take into account different techniques for the R&D and innovation management. The multidisciplinary approach and of projects developed by LANIA, has allowed this to manage its technology efficiently, facilitating transferring these approaches to the field of the technological development Whereas LATEX has managed its S&T activities on an methods and procedures approach.

SILANES and MABE are cases of firms that have implemented successful models of technology management. These models aim to integrate monitoring, planning and protection of technology in order to implement the various processes of innovation on the basis of the processes previously carried out. In this way, these firms have managed to capitalize on the experience and knowledge gained in the development of innovative products and processes. Moreover, the competitive advantages obtained by SILANES, have been the result of coordinated efforts under a strategic plan based on constant innovation in processes and products, and through the program of technology management underpinned by a strong industry-university linkage.

To SYCSA the model for technology management developed recently will allow to dynamic and capitalize on internal and external knowledge. STREGER does not use any technology management approach in order to integrate these techniques throughout the innovation process. However, successful innovation depends not only on an external, clear and effective strategic positioning, but also be able to manage projects from initial idea or opportunity until commercial success of products or services, or new effective processes. Thus, the profiles (organizational and technological) are influenced one another developing a spiral of mutual growth (maturity organizational and technological level). Such aspects delimit its technological capacity, defining at the same time a singular profile for each organization (Figure 6).

Figure 6. Organizational and technological evolution of the organizations.

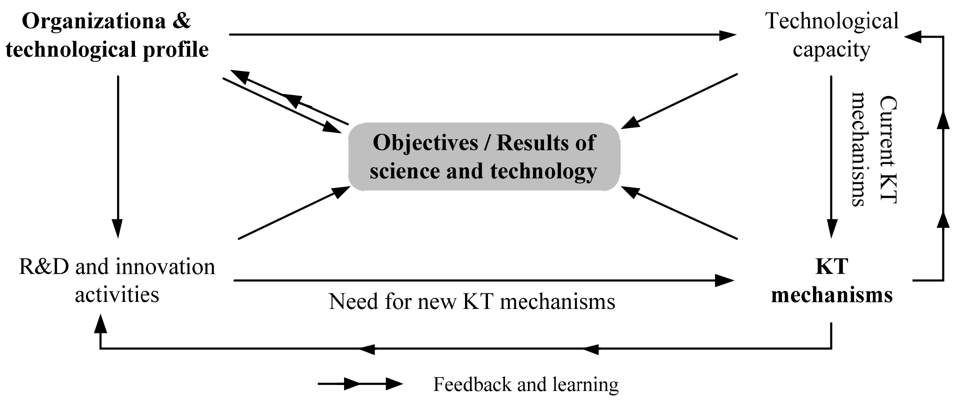


4.3.. Knowledge transfer profile

4.3.1. KT Mechanisms

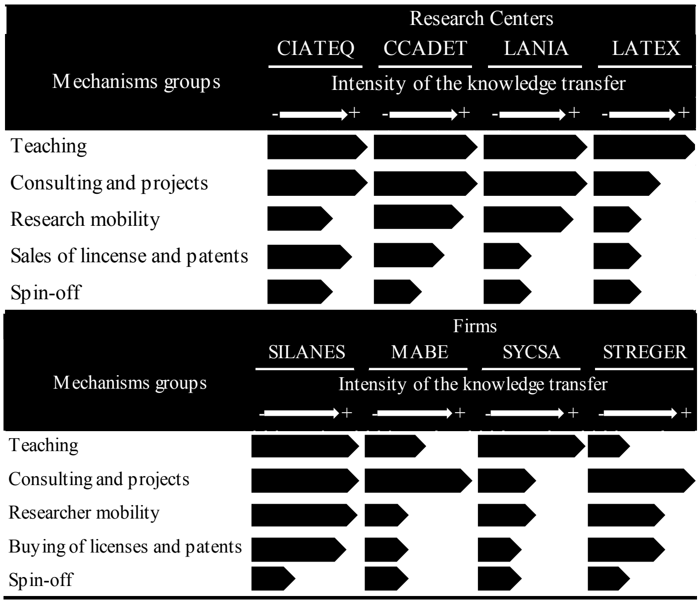
These profiles (or technological capabilities) allow the identification of the KT mechanisms best suited to their capabilities, thus enabling the establishment of cooperative processes. However, these mechanisms will depend on some degree of technological capabilities of these organizations. So, the objectives pursued by these organizations (based on the R&D and innovation) will dictate the selection of the best mechanisms to achieve them, while providing the feedback and learning processes (Figure 7).

Figure 7. The selection of KT mechanisms.



In this context, the analysis shows that although most research centers make use of these mechanisms, the intensity differs widely among all research centers. In fact, the highest level of intensity in KT activities takes place in the teaching and flow of graduates group (Table 9). This means that in addition to developing R&D and innovation activities, much of the S&T effort is focused to generate intellectual capital through the human factor. The extent of this relationship is often limited and unidirectional, it do not create a learning situation and long-term benefits for both organizations.

Table 9. Analysis of KT mechanisms in the research centers and firms.



For the mechanisms that are considered critics for the KT processes (by the amplitude of its scope, and the actions of mutual learning) such as R&D and innovation consultancy/projects, the most of the research centers analyzed develops these activities with diverse degrees of intensity. On the other hand, there is a limited mobility of researchers within these projects with firms (not between research centers), even so, within the considered successful experiences, are those that make reference to the high interaction that occurs between the personnel and the firms within the technological development projects (e.g., CIATEQ). In LANIA, its practical focus and of service to firms has facilitated the KT process.

The marketing of licenses, patents and intellectual property rights and creation of technology-based firms are the cooperative and KT activities less developed by most research centers, although the experience developed by CIATEQ in creating six technology-based firms (spin-off) is highlighted. Bases on the analysis of relations level developed by the firms, it is possible to observe that while the majority of them make use of five types of mechanisms (graduate flows, consulting and projects, mobility, industrial property, and spin-offs), the intensity with which they are applied differs both between the mechanisms as the firms.

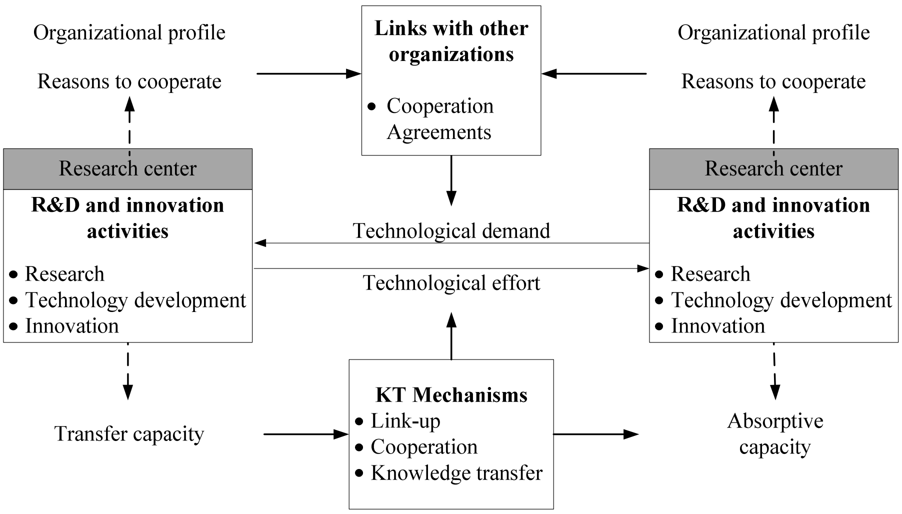
These firms have contributed to economy and society in an important way to train professionals and researchers by providing learning environments for graduate and post-graduated students as well as linking spaces between the academic and productive environment. Firms like SILANES and MABE keep cooperative programs with some national and international academic institutions through which they promotes the talent formation and development. SYCSA has an ongoing program of knowledge management with universities through the so-called virtual residences (shelf e-learning), besides having a college course that is taught within the firm as part of formation of the university. With regard to consulting and projects, it appears that most firms have extensive experience developing these mechanisms. In the analyzed firms predominate MABE and SILANES (like pioneers in their sector) standing out to maintain the largest number of collaborative agreements conducted with research centers. This interaction also allowed them to be placed at the frontier of knowledge and to stimulate the training of high level. STREGER commonly uses these mechanisms to varying degrees of application. Although the mobility of researchers and teachers as a means of KT is not a priority for most evaluated firms, highlights the synergy created between this activity and the R&D and innovation projects carried out by SILANES.

The management of industrial property rights (IPR) is a mechanism that has low weight compared with the other because IPR has a low use inside the technological development. Finally, the creation of technology-based firms is not an activity commonly carried out by all the analyzed firms. However, the Bioclón Institute in SILANES and the Technology Development Center in SYCSA are two examples of technology-based firms created based on a specific market need.

4.3.2. Links with other organizations

At the level of the KT processes, the effectiveness of such mechanisms will depend of the agreements scope (formal or informal), which regulate the activities associated with the KT mechanisms used (Figure 8). Such links are the result of both the organizational profile as the reasons expressed by the organizations to undertake such KT processes.

Figure 8. Links in the KT processes.

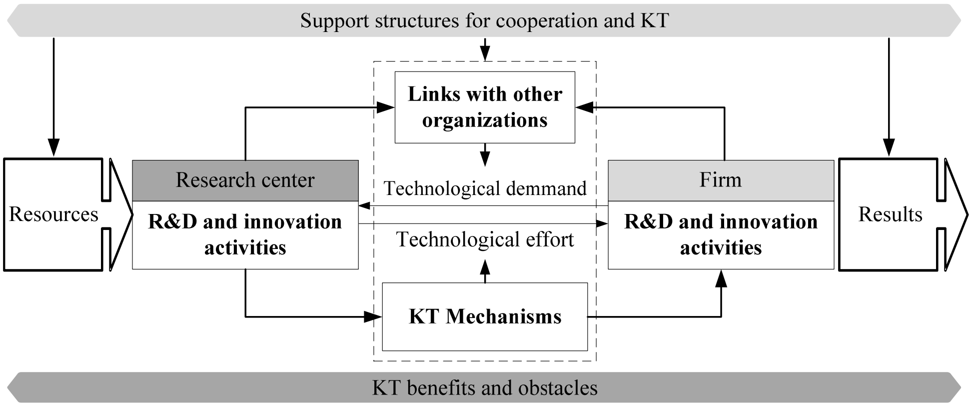


Although all research centers develop links with a wide variety of organizations (research center and firms – public and private), only CCADET has a unit for cooperation and KT. Unlike the research centers, The KT environment of the firms is mostly limited to maintain these links with research centers and to a minor degree (in the case of SYCSA) with other firms. In fact, SILANES created a KT unit (the Bioclón Institute) with the strategic decision of exploring new markets for biotechnological products and the development of new technology, through cooperation with other organizations (research centers and firms). Similarly, MABE created the department of Strategic Alliances and Technology Link with the aim to support the KT processes. These situations leads to conclude that such organizations are better prepared and more willing to build more formal relationships to rely on specialized infrastructure as opposed to other organizations which create their knowledge through informal relationships.

4.3.3. Structures to KT support

An important limitation to realization of S&T activities through KT mechanisms is the limited availability of KT supporting structures. These do not exist or are very rare in Mexico. The supporting structures most requested by the analyzed organizations are structures belonging to the same organizations (other research centers or units located in different regions), or organizations associated with various cooperation networks and networks of experts (like SILANES and MABE). Industry associations are other structures; however, all organizations agree that structure mostly used is the National Council for Science and Technology (CONACYT) (Figure 9). Even so, although the structures supporting cooperation in Mexico are scarce, the main perceived problem is the lack of understanding in the use of the KT mechanisms with respect to the expected results and available capacity.

Figure 9. KT support structures.



4.4.Motivations

4.4.1. Benefits

The analysis shows that all relations between the evaluated aspects are largely influenced by a number of reasons, which have facilitated or hindered the development of S&T activities based on KT processes. The reasons why organizations decide to use those links and KT mechanisms are often different and varied and can occur at any stage of projects: from the search for specific problems solutions, technical assistance, training for the domain of technology, improvement and development of new products, or to the exploitation of new knowledge for its incorporation into new products. In this way, research centers emphasize the acquisition of external knowledge and the collection of economic resources as a means to enhance their intellectual capital and their continuity. Other benefits are those that make reference to the knowledge of the market, the consolidation of the relations, the recognition and the extension of the access to the financing offered by diverse sources.

For the analyzed firms, the benefits of R&D and innovation and its interaction with other organizations are those that relate primarily to development and improvement of products and processes. While scientific-technological results are important, the main impact comes from capitalizing on the knowledge acquired externally through the creation of internal capacity, innovative new products and improving processes through problem solving and cost reduction.

4.4.2. Obstacles

With respect to resulting obstacles from the R&D and innovation and their interaction with other organizations, all organizations are focused on those that refer to low culture and erroneous perceptions regarding the R&D and innovation in both directions. Moreover, there is no real empathy between firms and scientific institutions from the cultural, institutional, regulatory and legal point of view. The research centers affirm that S&T legislation is out of phase with respect to the needs of the country. Mexico lacks an innovation policy which allows stimulating the interactions of the research centers with the firms. Firms show that most of the R&D and innovation projects developed are of low technological content, so that the facilities in order to establish communication links between research institutes and firms are often scarce. Firms warn that government and public institutions in Mexico offer a limited help, support and benefits to firms trying to undertake R&D and innovation activities. Excessive bureaucracy with regard to obtaining R&D and innovation funds tends to discourage the attempt of firms to undertake S&T activities. In fact, the university laws are often one of the greatest impediments to transfer scientific results to the firms so that the rigidity of the education and research structures limit the KT process.

5. Conclusions and future research

The results of the application of model reveal the need to improve the KT and cooperative processes in relation to the S&T activities developed by the organizations. At the level of cooperative relations, it is noted that most of these organizations make use of all mechanisms. However, the intensity with which they are applied to vary greatly between the mechanisms and among similar organizations. This is because, although all develop their R&D and innovation activities in different degrees of intensity, the analysis shows several weaknesses with respect to the form to transfer (and absorb) the S&T results. Although the profiles of the organizations are an important condition for the R&D and innovation development, and KT activities, is observed most of these limitations are rooted in knowledge searched with regard to lack of understanding about activities and tools applied to get it, and the KT mechanisms used to absorb externally or transfer internally this knowledge. The experience and maturity of the organizations are highlighted in a major way as a key factor in the implementation of various management approaches (such as project, knowledge or technology management). Also, the analysis shows the existence of a close relationship among all the factors raised in the study. Moreover, the successful implementation of such KT mechanisms is largely determined by four important factors: strategic planning and the resulting technology plan, the innovative approach, techniques and tools for managing the R&D, and technology management mode.

At the level of the mechanisms are unknown the scope and limitations of each, perceiving that most of firms ignore the conditions and implications of using such mechanisms. This has important implications for the processes of learning and knowledge generation, because depending on the mechanism used, will be the intensity of the transferred knowledge and developed learning. Such weakness is not limited only to the analyzed organizations, reaching the field of public administration. Therefore, understanding the use of such KT mechanisms by all organizations (including public administration) will allows: the redirection of the R&D activities in the research centers to the technological needs of firms in order to broaden the participation of these in productive activities, and to affect the creation of new policies and the redirection of existing R&D and innovation programs, allowing also the alignment of the available resources to R&D and innovation and KT activities, aiming to achieve the results set.

The relations presented in the model are focused to fill the gaps found in the KT processes. Then, the main objective to Mexico should be focus in the recognition of the need to formalize the R&D activities within the firm, the need to improve the cooperation and KT processes with focus to S&T activities developed by firms, and to recognize it as sources of information (beyond marketing activities) for development of new products and improvement processes. Furthermore, is emphasized the need to manage S&T activities beyond R&D departments, to align the sources of information, techniques and mechanisms of cooperation and KT to these, as well to recognize of the various cooperation and KT mechanisms as key elements of the R&D and innovation processes.

Therefore, some future work should include the definition of the methodology of implementation of the proposed model, the analysis of the several technological profiles in diverse organizations, in order to: analyze and to determine their technological profile, aiming to aligning and balancing available resources and desired outcomes to activities and sources of scientific and technological information, and assess the KT mechanisms based on the objectives, strategies and the capabilities of the firms, with the aim of improving the effectiveness of knowledge transfer processes.

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